PATENT ABSTRACTS OF JAPAN

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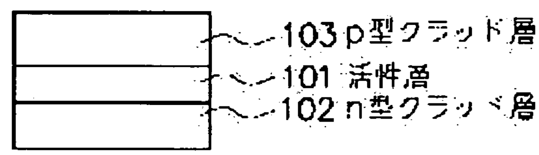
(54) SEMICONDUCTOR LIGHT EMITTING ELEMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a semiconductor light emitting element of a light from a green to an ultraviolet wide region considering an environment by using a hexagonal crystal ZnO material.
SOLUTION: An active layer 101 contains at least element Zn and element O. The layer 101 further contains at least one kind of S, Se and Te. At least one of clad layers 102 and 103 contains element Zn and element O. The layer 101, the layers 102 and 103 are made of hexagonal crystals. The hexagonal ZnO has a large exciton bonding energy. The exciton of high density exists even at the ambient temperature. Accordingly, a high light emission efficiency is expected. A light emitting layer contains a composition of a hexagonal crystal Zn (OX) (X=Se, Se or Te) mainly containing the hexagonal crystal ZnO. Similarly, a high light emitting efficiency is expected.



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CLAIMS

[Claim(s)]
[Claim 1] In a semiconductor light emitting device which has one or two cladding layers using a barrier layer and this II-VI group compound semiconductor using an II-VI group compound semiconductor Said barrier layer is Zn element and O at least. An element is included and said barrier layer is S, Se, and Te further. At least one or more sorts of elements are included inside. At least one of said the cladding layers is Zn element and O. A semiconductor light emitting device characterized by crystal system of said barrier layer and said cladding layer being hexagonal system, including an element.
[Claim 2] At least one or said barrier layer is Mg and Mn among said cladding layers. A semiconductor light emitting device according to claim 1 characterized by including at least one sort of elements inside.
[Claim 3] One or more or said barrier layer of said cladding layer is N. A semiconductor light emitting device according to claim 1 or 2 characterized by including an element.
[Claim 4] Said barrier layer and said cladding layer are aluminum 2O3. A semiconductor light emitting device given in either of claims 1-3 characterized by being prepared on a substrate.
[Claim 5] Said barrier layer and said cladding layer have hexagonal structure, and a lattice constant A semiconductor light emitting device given in either of claims 1-3 characterized by being prepared on a substrate which is a=2.7-5.2 **.
[Claim 6] Said substrate is ZnO and SiC. A semiconductor light emitting device according to claim 5 characterized by being either.
[Claim 7] A semiconductor light emitting device given in either of claims 1-6 characterized by preparing a buffer coat which eases a mismatch of a grid between said substrates and said cladding layers.
[Claim 8] Said buffer coat is Zn element, and O, S, Se and Te. A semiconductor light emitting device according to claim 7 characterized by consisting of any one or more sorts of element compounds.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention relates to the semiconductor light emitting device using an II-VI group compound semiconductor about a semiconductor light emitting device.
[0002]
[Description of the Prior Art] Conventionally, a semiconductor light emitting device is constituted for example, using an II-VI group compound semiconductor. It is GaN as a light emitting device of recent years and blue to an ultraviolet region. The system has been put in practical use. Recently and bandgap energy are GaN. Hexagonal ZnO with the very large binding energy of near and an exciton It has been observed as a material which may be able to realize more efficient laser diode of an ultraviolet region from blue ("patent No. 2996928").
[0003] ZnO bandgap energy -- 3.2eV it is . When using as a light emitting device, in order to obtain required luminescence wavelength, the band gap control technology which makes a band gap small greatly is needed. as this energy band gap control technology -- ZnO MgO CdO it dissolves -- making -- MgZnO ****** -- wide -- a gap ---izing -- CdZnO ****** -- the method of forming into a narrow gap is indicated (the collection of the 58th Japan Society of Applied Physics scientific lecture meeting lecture drafts besides Sakurai, and pp281 (1997)).
[0004] "the OPTO semiconductor device and its process method" of the example 1 ("patent No. 2996928") of a prior invention -- ZnO from -- the becoming thin film is made into a luminous layer, the grain boundary which exists in this thin film is used as a resonator, and laser oscillation by the exciton in a room temperature is made possible. By this configuration, it is Nd:YAG 1/3. Wavelength laser light is made into excitation light, and it is 3.15-3.2eV. The example which carries out laser oscillation in the luminescence wavelength of a field is shown.
[0005] the "semiconductor light emitting device" of the example 2 ("JP,9-162500,A") of a prior invention -- the inside of Zn, Mg, Cd, Hg, and Be -- at least one sort of elements, and Se, S, Te and O the semiconductor light emitting device using the II-VI group compound semiconductor which consists of at least one sort of elements inside -- setting -- the lattice constant of a barrier layer -- about [the lattice constant of a substrate, and] -- the semiconductor light emitting device which I am doing one is indicated.
[0006] "The semiconductor light emitting device and the optical equipment" of the example 3 ("JP,11-150337,A") of a prior invention Zn, Mg, Cd, Be, Mn, and Hg Inside At least one sort of elements, O, S, Se, and Te In the semiconductor light emitting device which has the 1st conductivity-type cladding layer which consists of an II-VI group compound semiconductor which consists of at least one sort of elements inside, respectively, a barrier layer, and the 2nd conductivity-type cladding layer A barrier layer is O at least. It consists of an II-VI group compound semiconductor containing an element. It is O to this II-VI group compound semiconductor material. By adding an element, the lattice matching of the formation of a wide gap and substrate of a barrier layer is reconciled. As a substrate, they are GaAs, and InP, GaP and SiC. The example to be used is given.
[0007] the compound semiconductor light emitting device which consists of two or more epitaxial growth phases by which the "compound semiconductor light emitting device" of the example 4 ("patent No. 2564024") of a prior invention was formed on the substrate -- setting -- a substrate -- ZnS it is -- this substrate top -- ZnS1-x Ox ZnO formed through the buffer coat a top -- Ga1-y Iny N It is the compound semiconductor light emitting device which consists of a configuration which deposited the layer. This example 4 of a prior invention is InGaN. ZnO with sufficient grid consistency The method of using as furring at the time of epitaxial growth is indicated. Moreover, MBE The production method of these elements by law is also indicated.
[0008] "The compound semiconductor light emitting device and its manufacture method" of the example 5 ("patent No. 2593960") of a prior invention In the compound semiconductor light emitting device which consists of two or more epitaxial growth phases formed on the substrate a substrate -- ZnS and ZnSe -- it is -- this substrate top -- ZnS1-x Ox Or ZnS1-xSex from -- ZnO formed through the becoming buffer coat Upwards Ga1-y Iny N A layer or aluminum1-y Iny N The compound semiconductor light emitting device which consists of a configuration which deposited the luminous layer which consists of a layer is indicated. Moreover, MBE The production method of these elements by law is also indicated. In addition, a buffer coat is prepared in order to make lattice matching of InGaN, AlInN, and a substrate good.
[0009]
[Problem(s) to be Solved by the Invention] However, luminescence reinforcement falls by the grid mismatch of a substrate and a barrier layer, and transition density increases, and the semiconductor light emitting device which used II-VI group compound semiconductors, such as the above-mentioned conventional ZnCdSe, for the barrier layer imitates deterioration of an element, and is accompanied by the trouble of **.
[0010] Moreover, since the method of the above-mentioned conventional formation of a wide gap uses Cd element in order to obtain luminescence of the light, it is not desirable on environment. It is O to an II-VI group compound semiconductor material as a method of on the other hand reconciling the lattice matching of the formation of a wide gap and substrate of a barrier layer of a semiconductor light emitting device which used II-VI group compound semiconductors, such as the conventional ZnCdSe, for the barrier layer. By adding an element, the method of changing a band gap and a lattice constant widely is indicated ("JP,9-162500,A", "JP,11-150337,A").
[0011] The material currently concretely raised with these conventional examples is ZnMgSSe, ZnBeSSe, ZnBeSe, and ZnBeS as a cladding layer. It is shown, ZnSSe, ZnSe, and ZnS are shown as a barrier layer. They are mainly the zinc blend structure GaAs of cubic system, InP and GaP, and ZnSe as a substrate. It is mentioned.

[0012] These methods are ZnO of hexagonal system, although it is applicable to amelioration of the semiconductor light emitting device which used the II-VI group compound semiconductor of the conventional cubic system. It is directly inapplicable to the light emitting device using a system.
[0013] This invention is ZnO of the hexagonal system which can desire a well head since the binding energy of an exciton is very large. It aims at offering the semiconductor light emitting device of a large ultraviolet field light from the green which considered environment using the system material.
[0014]
[Means for Solving the Problem] In order to attain this object, a semiconductor light emitting device according to claim 1 In a semiconductor light emitting device which has one or two cladding layers using a barrier layer and this II-VI group compound semiconductor using an II-VI group compound semiconductor A barrier layer is Zn element and O at least. An element is included and a barrier layer is S, Se, and Te further. At least one or more sorts of elements are included inside. At least one of the cladding layers is Zn element and O. It is characterized by crystal system of a barrier layer and a cladding layer being hexagonal system, including an element.
[0015] For invention according to claim 2, it sets to a semiconductor light emitting device of ****** at claim 1, and at least one or a barrier layer is Mg and Mn among cladding layers. It is characterized by including at least one sort of elements inside.
[0016] For invention according to claim 3, it sets to a semiconductor light emitting device according to claim 1 or 2, and one or more or a barrier layer of a cladding layer is N. It is characterized by including an element.
[0017] For invention according to claim 4, it sets to a semiconductor light emitting device given in either of claims 1-3, and a barrier layer and a cladding layer are aluminum 2O3. It is characterized by being prepared on a substrate.
[0018] In a semiconductor light emitting device given in either of claims 1-3, a barrier layer and a cladding layer have hexagonal structure, and a lattice constant invention according to claim 5 It is characterized by being prepared on a substrate which is a=2.7-5.2 **.
[0019] For invention according to claim 6, it sets to a semiconductor light emitting device according to claim 5, and a substrate is ZnO and SiC. It is characterized by being either.
[0020] Invention according to claim 7 is characterized by preparing a buffer coat which eases a mismatch of a grid between a substrate and a cladding layer in a semiconductor light emitting device given in either of claims 1-6.
[0021] For invention according to claim 8, it sets to a semiconductor light emitting device according to claim 7, and a buffer coat is Zn element, and O, S, Se and Te. It is characterized by consisting of any one or more sorts of element compounds.
[0022]
[Embodiment of the Invention] Next, with reference to an accompanying drawing, the gestalt of operation of the semiconductor light emitting device by this invention is explained to details. If drawing 8 is referred to from drawing 1 , 1 operation gestalt of the semiconductor light emitting device of this invention is shown.
[0023] In the semiconductor light emitting device which has one or two cladding layers using the barrier layer and II-VI group compound semiconductor using an II-VI group compound semiconductor (Example 1 of a configuration) Said barrier layer is Zn element and O at least. An element is included and they are S, Se, and Te. At least one or more sorts of elements are included inside, and at least one of these the cladding layers is Zn element and O. The crystal system of this barrier layer and this cladding layer is hexagonal system, including an element.
[0024] Hexagonal ZnO Since exciton binding energy is large and the exciton of high density exists also in a room temperature, high luminous efficiency can be expected (above-shown "patent No. 2996928"). the luminous layer of this invention is hexagonal -- ZnO Since it is the presentation of hexagonal Zn(OX) (X=S, Se, Te) made into the subject, high luminous efficiency can be expected similarly.
[0025] The semiconductor light emitting device of this invention is concerned with all the semiconductor laser elements and light emitting diode elements which have a barrier layer and a cladding layer. If the example of a configuration is given, they will be a single heterojunction mold, a double heterojunction mold, and a separation ****** heterojunction (SCH). Although a mold and a multiplex quantum well structured type are raised, it does not limit to these.
[0026] A double heterojunction mold shows the basic configuration of this invention to drawing 1 . If an example is given as a material of a barrier layer 101, hexagonal Zn (OS), Zn (OSe), Zn (OTe), Zn (OSSe), Zn (OSeTe), Zn (OSTe), etc. will be raised.
[0027] If an example is given as a material of n mold cladding layer 102, hexagonal ZnO, Zn (OS), Zn (OSe), Zn (OTe), Zn (OSSe), Zn (OSeTe), Zn (OSTe), etc. will be raised.
[0028] Voltage is impressed between p mold cladding layer 103 and n mold cladding layer 102, an electron hole and an electron are impregnation - Confined in the barrier layer 101 prepared between p mold cladding layer 103 and n mold cladding layer 102, and luminescence takes place. The light which emitted light is confined in a barrier layer, and is guided. In the case of a semiconductor laser element, this waveguide light is amplified by taking the optical-resonator structure by end-face echo etc. further. For this reason, it is necessary to make the band gap of n mold cladding layer 102 larger than the band gap of a barrier layer 101. Furthermore, it is necessary to make the refractive index of p mold cladding layer 103 smaller than the refractive index of a barrier layer 101. Below, this condition is called the conditions of laser lamination for convenience.
[0029] In addition, below, it is SCH for convenience. The well layer of a mold and a quantum well structured type semiconductor laser element is called a barrier layer, a call and a barrier layer, and a guide layer, and a cladding layer is called a cladding layer. ZnO, ZnS, ZnSe, and ZnTe ZnO of the hexagonal system which is mixed crystal The configuration of the barrier layer and cladding layer which satisfy the conditions of the above-mentioned laser lamination into a system material is considered. The value of the lattice constant of the hexagonal system II-VI group compound semiconductor which uses Zn as II group element, a band gap, and a refractive index is shown in a table 1. Furthermore, as shown in drawing 3 , in order to grasp said physical properties of the mixed crystal of these compound semiconductors, between the plots of the physical-properties value of each compound semiconductor is connected in a straight line. The physical properties between each II-VI group compound semiconductor are acquired with the mixed crystal of these II-VI group compound semiconductors. Lattice matching is acquired by these examination and the following is raised as an example of combination of the material which may fulfill the above-mentioned conditions.
[0030]
Zn(OTe)-(barrier layer) Zn (OSe) (cladding layer) Zn(OSTe) (barrier layer)-Zn (OSSe) (cladding layer), Zn(OSeTe)-(barrier layer) Zn (OSeTe) (cladding layer) : there are more Te contents of a barrier layer than Te content of a cladding layer.
[0031] Since the mismatch of a lattice constant is permitted to the degree by which the grid of a barrier layer is not destroyed when forming a deformation amount child well structured type luminous layer, the selection range of the combination of a

material spreads further.
[0032]
[A table 1]
ウルツアイト構造II－VI族半導体の物性表

材料	結晶構造	格子定数 a (Å)	バンドギャップ (eV)	屈折率
ZnO	ウルツアイト	3.24	3.2	2.2
ZnS	ウルツアイト	3.87	3.66	2.7
ZnSe	ウルツアイト	4.00	2.71	2.6
ZnTe	ウルツアイト	4.27	2.28	2.9

[0033] (Example 2 of a configuration) At least one or a barrier layer is Mg and Mn among the above-mentioned cladding layers. Semiconductor light emitting device ZnO of the example 1 of a configuration characterized by including at least one sort of elements inside By adding Mg, it is hexagonal system Mgx Zn1-x O of an epitaxial film. It is obtained in x= 0-0.36. A band gap is 3.2-4.0eV in the increment in the addition of Mg. It increases (the collection of the 58th Japan Society of Applied Physics scientific lecture meeting lecture [besides Sakurai] drafts, and pp281 (1997)). Moreover, a refractive index decreases with the increment in the addition of Mg. ZnO By adding Mn, it is hexagonal system Mny Zn1-y O of a high orientation film. It is obtained in y= 0-0.35. A band gap increases to 3.2-3.75eV with the increment in the addition of Mg (T. Fukumura et al., Appl.Phys.Lett., 3366 (1999)).
[0034] If the example of this example 2 of a configuration is given, therefore, O (MgZn) of hexagonal system, ((MgZn) OS), (MgZn) (OSe), (OSSe (MgZn)) (OTe (MgZn)) (MgZn) (OSeTe), O (MnZn), ((MnZn) OS), (OSTe (MgZn)) (MnZn) (OSe) (OTe (MnZn)) (OSSe (MnZn)) (OSeTe (MnZn)) (OSTe (MnZn)) etc. — it is raised.
[0035] If the film of these plural systems is used for the cladding layer of this invention, and a barrier layer, the selection range of the combination of the material of laser lamination will become large. Therefore, the film of this example of operation is suitable for using it for the quantum well structured type semiconductor laser element of complicated laser lamination etc.
[0036] In the case of a quantum well structured type semiconductor laser element, it is necessary to be the following.
A band gap is a cladding layer > guide layer > well layer. A refractive index Cladding layer < guide layer < well layer A lattice constant Cladding layer = when a guide layer (=or!=) well layer lattice constant is a guide layer != well layer, it is the case of a deformation amount child well structured type semiconductor laser element.
[0037] The example of a configuration in the material of the plural systems of this invention is shown.
(MgZn) (OSe) Cladding layer - (MgZn) (OSe) Guide layer-Zn (OTe) Well layer (MgZn) (OSe) Cladding layer - (MgZn) (OSe) Guide layer-Zn (OSe) Well layer (MgZn) (OSe) Cladding layer-Zn (OSe) Guide layer-Zn (OTe) well layer (MnZn) (OSe) Cladding layer - (MnZn) (OSe) Guide layer-Zn (OTe) Well layer (MnZn) (OSe) Cladding layer - (MnZn) (OSe) Guide layer-Zn (OSe) Well layer (MnZn) (OSe) Cladding layer-Zn (OSe) Guide layer-Zn (OTe) Well layer [0038] Thus, they are Mg and Mn to the above-mentioned cladding layer and a barrier layer. If an element is included, control of the physical-properties value of a material will become easier, and production of a complicated high performance light emitting device will be attained.
~~[0039]~~ (Example 3 of a configuration) It sets for the above-mentioned examples 1 or 2 of a configuration, and one or more or the barrier layer of a cladding layer is N further. An element is included.
[0040] Non dope ZnO Since an oxygen hole exists, n-type conduction is shown. Furthermore, they are B, aluminum, Ga, In, Si, and F. The conductivity of n mold is controllable by doping as a donor.
[0041] ZnO of p mold In order to obtain, it does not realize, although the method of doping Li, Ag, and Cu as an acceptor is tried. Recent years and ZnO N+ The method and CVD which perform implantation ZnO by law It is NH3 at the time of membranous growth. It is N by the method of adding gas. It is ZnO of p mold by doping. It has realized (KYano et al., Jpn.J.Appl.Phys., L1453 (1997)). If the above-mentioned doping technique is used, n mold cladding layer and p mold cladding layer are producible.
[0042] (Example 4 of a configuration) In either of the above-mentioned examples 1, 2, and 3 of a configuration, the barrier layer and the cladding layer are further prepared on the alpha-aluminum 2O3 substrate.
[0043] Since the atomic arrangement of the field (0001) of alpha-aluminum 2O3 (sapphire) has consistency with the atomic arrangement of a hexagonal (0001) field, the field (0001) of alpha-aluminum 2O3 (sapphire) is a. A role with a shaft equivalent to a 2.75A hexagonal system substrate is played.
[0044] As this example, it is MgO. It is ZnO on the field (0001) of alpha-aluminum 2O3 (sapphire) for minding a buffer coat. There is a report which carried out epitaxial growth (T. Yao, et al., Appl.Phys.Lett., 559 (2000)).
[0045] (0001) Mirror-polishing alpha-aluminum 2O3 (sapphire) is ZnO as mentioned above. It is usable as a substrate for the epitaxial growth of a system, and since it can obtain comparatively cheaply, it is suitable as a substrate of the element of this invention.
[0046] (Example 5 of a configuration) In either of the above-mentioned examples 1, 2, and 3 of a configuration, the barrier layer and the cladding layer are further prepared with hexagonal structure on the substrate which are a lattice constant a= 2.7 - 5.2 **.
[0047] As shown in the above-mentioned [table 1], the ranges of the lattice constant of the barrier layer material of this example 5 of a configuration are a= 3.2 - 4.7 **. ZnO on the field (0001) of alpha-aluminum 2O3 (sapphire) whose grid mismatch is 18% as mentioned above on the other hand The lattice constant of the substrate which can be used in this example 5 of a configuration is within the limits of a= 2.7 - 5.2 ** as it understands also from epitaxial growth being possible.
[0048] (Example 6 of a configuration) It sets for the above-mentioned example 5 of a configuration, and a substrate is ZnO and SiC further. Suppose that it is either. As a concrete material of the substrate which fulfills the conditions of the example 5 of a configuration, it is ZnO (hexagonal Ur Die Zeit structure a= 3.24A). Alpha-SiC (hexagonal Ur Die Zeit structure a= 3.08A) It is raised.
[0049] (Example 7 of a configuration) In either of the above-mentioned examples 1-6 of a configuration, the buffer coat which eases the mismatch of a grid between a substrate 204 and a cladding layer is prepared further.
[0050] Since the grid mismatch of the above-mentioned substrate material, a barrier layer 201, and a cladding layer is eased, the buffer coat 205 with the lattice constant between the lattice constants of the lattice constant of a substrate 204, a barrier layer 201, and a cladding layer may be formed between a substrate and a cladding layer. A double heterojunction mold shows the basic configuration of this example of a configuration to drawing 2 .

[0051] (Example 8 of a configuration) It sets for the above-mentioned example 7 of a configuration, and a buffer coat 205 is Zn element, and O, S, Se and Te further. It consists of a compound which consists of any one or more sorts of elements.
[0052] as an example — ZnO of hexagonal system, Zn (OS), and Zn (OSe), Zn (OTe), Zn (OSSe), Zn (OSeTe), Zn (OSTe), Zn (SSe), Zn (SeTe) and Zn (STe) etc. — it is raised. Furthermore, from a substrate 204, toward cladding layers 202 and 203, the presentation of these buffer coats 205 is made to incline, and may be established.
[0053] (Example 1) (0001) Mirror-polishing alpha-aluminum 2O3 (product made from SHINKOSHA Co., Ltd.) (hexagonal conversion 2.75A) H2SO4:H3PO4=3:1 after performing organic washing It etches by inside 160 **. It is MBE about this substrate. It installs in equipment. 1 Maintain at substrate temperature 400 ** under the back pressure of x10-8Pa.
[0054] It is molecular-beam reinforcement about Zn melting cel to Zn. In 1x10 to 4 Pa, it is O from O2 gas installation line at 2x10 to 5 Pa molecular-beam reinforcement about Se melting cel to Se. Molecular-beam reinforcement At 1x10 to 6 Pa, it is Zn (OSe) in 50nm of thickness by this growth process. Epitaxial growth of the buffer coat is carried out. This buffer coat 205 is hexagonal and is lattice constant a=3.3 **.
[0055] It is molecular-beam reinforcement about Zn melting cel to Zn. In 1x10 to 4 Pa, it is O from O2 gas installation line at 8x10 to 5 Pa molecular-beam reinforcement about Se melting cel to Se. Molecular-beam reinforcement At 1x10 to 6 Pa, it is molecular-beam reinforcement about aluminum(CH3) 3 installation line to aluminum. It introduces by 1x10 to 7 Pa. It is 500nm of thickness by this growth process. Zn (OSe) : aluminum Epitaxial growth of the n mold cladding layer is carried out. This n mold cladding layer is hexagonal, and is lattice constant a=3.4 **.
[0056] Next, it is molecular-beam reinforcement about Zn. At 1x10 to 4 Pa, it is molecular-beam reinforcement about Te melting cel to Te. At 8x10 to 5 Pa, it is O. Molecular-beam reinforcement At 1x10 to 6 Pa, it is molecular-beam reinforcement about aluminum(CH3) 3 installation line to aluminum. It introduces by 1x10 to 7 Pa. It is 400nm of thickness by this growth process. Zn (OTe) : aluminum n Epitaxial growth of the mold barrier layer is carried out. This n The mold barrier layer is hexagonal and is a= 3.4A in lattice constant.
[0057] Next, it is molecular-beam reinforcement about Zn. At 1x10 to 4 Pa, it is molecular-beam reinforcement about Se. At 8x10 to 5 Pa, it is O. Molecular-beam reinforcement At 1x10 to 6 Pa, it is NH3. An introductory line to N Molecular-beam reinforcement At 1x10 to 6 Pa, it is H from H2 installation line. It introduces by 1x10 to 5 Pa. It is 400nm of thickness by this growth process. Epitaxial growth of the p mold cladding layer of Zn(OSe):N is carried out. It is hexagonal and this p mold cladding layer is a lattice constant. It is a= 3.4A.
[0058] Next, it is molecular-beam reinforcement about Zn. At 1x10 to 4 Pa, it is molecular-beam reinforcement about Se. At 8x10 to 5 Pa, it is NH3. An introductory line to N Molecular-beam reinforcement At 1x10 to 5 Pa, it is H from H2 installation line. It introduces by 1x10 to 5 Pa. It is 200nm of thickness at this growth process. ZnSe: N Epitaxial growth of the p mold contact layer is carried out.
[0059] Next, a laser element processing process is performed. It is plasma CVD about a sample. It sets in equipment and is 200nm of thickness. The laminating of the SiO2 film is carried out. BHF By the etching process, it is width of face of 10 micrometers to this SiO2 film. While forming a stripe-like slot, it is this width of face of 10 micrometers. It is width of face 100 centering on a stripe-like slot. mum It leaves SiO2 film. After performing resist spreading in this sample, it has consistency into the slot of the shape of a stripe of this SiO2 film, and the slot on the resist is formed.
[0060] Next, a sample is set to a vacuum evaporationo machine, the laminating of the Pd/Pt/Au film is carried out one by one, and p-electrode layer is formed. By the lift-off method, it is width of face of 10 micrometers. p mold electrode is formed. Next, a sample is set in a dry etching system and it is Cl2. Gas is used and it is width of face 100 centering on the slot of the stripe of SiO2 film. mum It leaves a stripe and is 100nm from the interface of n mold cladding layer and a barrier layer. It etches by Fukashi. It is width of face of 40 micrometers to n mold cladding layer front face which carried out dry etching after performing resist spreading in a sample. A stripe-like slot is formed. It is width of face of 40 micrometers by the lift-off method after setting a sample in vacuum evaporationo equipment and vapor-depositing In film. n mold electrode is formed.
[0061] It is cavity length 500 by the dry etching method containing photolithography. mum An element is formed. By the above-mentioned process, it is the luminescence wavelength of 415nm near a room temperature. A double heterojunction mold semiconductor laser element is produced. The cross section of this element is shown in drawing 4 .
[0062] (0001) Zn with the lattice constant between 2Omirror-polishing alpha-aluminum 3 substrate and the above-mentioned luminous layer (OSe) Since the buffer coat 305 is used, a quality epitaxial growth cladding layer can be obtained. Furthermore, O-Se and O-Te It is Zn (OTe) by adjusting the presentation ratio of a between. A barrier layer 301 and Zn (OSe) Since the lattice matching between a cladding layer 302 and 303 can be acquired, a good epitaxial growth luminous layer is obtained about a wide gap, it is efficient and the semiconductor laser element of highly reliable short wavelength can be obtained.
[0063] (Example 2) H2SO4:H3PO4=3:1 after performing organic washing for mirror-polishing alpha-aluminum 2O3 (0001) It etches at 160 degrees C inside. It is horizontal-type quartz ****** CVD about this substrate. It installs in equipment. It maintains at substrate temperature 500 ** after exhausting to 1x10 to 4 Pa. The pressure in all the following processes is 133Pa. It carries out.
[0064] They are [Mg / (C5H7O2) /2 (bisacetylacetonatomagnesium) (Made in a TORIKEMIKARU Lab)] 80sccm(s) and H2O about 120sccm(s) and Se (CH3)2 in an equivalent for 60sccm(s), and Zn (CH3)2. They are 5sccm(s) about 200sccm(s) and aluminum (CH3)3 in 20sccm(s) and H2. It introduces. Mg (C5H7O2)2 The above-mentioned 200sccm H2 is introduced as carrier gas. At this time, it is H2O. It introduces from the nozzle near the sample. It is 400nm of thickness by this growth process. : (OSe (MgZn)) aluminum Epitaxial growth of the n mold cladding layer is carried out. This n mold cladding layer is hexagonal, and is lattice constant a=3.3 **.
[0065] Next, they are 100sccm(s) and H2O about 120sccm(s) and Se (CH3)2 in Zn (CH3)2. They are 5sccm(s) about 200sccm(s) and aluminum (CH3)3 in 10sccm(s) and H2. It introduces. Similarly, it is H2O. It introduces from the nozzle near the sample. It is 400nm of thickness by this growth process. Zn (OSe) : aluminum Epitaxial growth of the n mold barrier layer is carried out. This n mold barrier layer is hexagonal, and is lattice constant a=3.3 **.
[0066] Next, Mg (C5H7O2)2 (bisacetylacetonatomagnesium) They are 80sccm(s) and H2O about 120sccm(s) and Se (CH3)2 in an equivalent for 60sccm(s), and Zn (CH3)2. It is 20sccm(s) and H2 200sccm(s) (it serves as carrier gas), and NH3 50sccm installation is carried out. Similarly, it is H2O. It introduces from the nozzle near the sample. It is 400nm of thickness by this growth process. : (OSe (MgZn)) Epitaxial growth of the p mold cladding layer of N is carried out. This p mold cladding layer is hexagonal, and is lattice constant a=3.3 **.
[0067] Next, it is 120sccm(s) and H2 about 120sccm(s) and Se (CH3)2 in Zn (CH3)2 200sccm(s) and NH3 They are 5sccm(s) about 50sccm(s). It introduces. It is 200nm of thickness at this growth process. ZnSe: N Epitaxial growth of the p mold contact

layer is carried out.
[0068] Next, the same processing process as an example 1 is performed, and it is the luminescence wavelength of 400nm near a room temperature. A double heterojunction mold semiconductor laser element is produced. The cross section of this element is shown in drawing 5 .
[0069] It is Zn (OSe) by adjusting the presentation ratio between Mg-Zn and O-Se further, since alpha-aluminum 2O3 with near luminous layer and lattice constant is used as a substrate. Barrier layer (OSe (MgZn)) The lattice matching between cladding layers was able to be acquired. For this reason, a good epitaxial growth luminous layer is obtained about a wide gap, it is efficient and the semiconductor laser element of highly reliable short wavelength can be obtained.
[0070] (Example 3) (0001) Mirror-polishing single crystal ZnO rare, after carrying out organic washing of the substrate (product made from Litton Airtron) (hexagonal [of a= 3.25A]) -- HCl Light etching is performed. It is MBE about this substrate. It installs in equipment. It maintains at substrate temperature 400 ** under the back pressure of 1x10 to 8 Pa.
[0071] It is molecular-beam reinforcement about beginning and Zn melting cel to Zn. At 1x10 to 4 Pa, it is O molecular-beam reinforcement from O2 gas installation line. It introduces by 1x10 to 4 Pa. In the growth passage of time, it is O. Molecular-beam reinforcement It is made to decrease up to 1x10 to 6 Pa, and is from 0 Pa about molecular-beam reinforcement in Se from Se melting cel simultaneously. It is made to increase up to 8x10 to 5 Pa. this growth process -- 50nm of all thickness -- the lattice constant of a= 3.25A -- hexagonal -- ZnO from -- hexagonal Zn (OSe) of lattice constant a=3.6 ** up to -- epitaxial growth of the presentation dip buffer coat which changes continuously is carried out.
[0072] It is molecular-beam reinforcement about Zn melting cel to Zn. At 1x10 to 4 Pa, it is Mg molecular-beam reinforcement from Mg(C5H7O2) 2 (bisacetylacetonatomagnesium) installation line. By 2x10 to 5 Pa It is molecular-beam reinforcement about Se melting cel to Se. At 8x10 to 5 Pa, it is O from O2 gas installation line. Molecular-beam reinforcement At 1x10 to 6 Pa, it is molecular-beam reinforcement about aluminum(CH3) 3 installation line to aluminum. It introduces by 1x10 to 7 Pa. It is 500nm of thickness by this growth process. : (OSe (MgZn)) aluminum Epitaxial growth of the n mold cladding layer is carried out. This n mold cladding layer is hexagonal, and is lattice constant a=3.6 **.
[0073] Next, it is molecular-beam reinforcement about Zn. At 1x10 to 4 Pa, it is molecular-beam reinforcement about Te melting cel to Te. At 1x10 to 4 Pa, it is O. Molecular-beam reinforcement At 1x10 to 6 Pa, it is molecular-beam reinforcement about aluminum(CH3) 3 installation line to aluminum. It introduces by 1x10 to 7 Pa. It is 400nm of thickness by this growth process. Zn (OTe) : aluminum n Epitaxial growth of the mold barrier layer is carried out. This n mold barrier layer is hexagonal, and is a= 3.6A in lattice constant.
[0074] Next, it is molecular-beam reinforcement about Zn. At 1x10 to 4 Pa, it is Mg molecular-beam reinforcement from Mg (C5H7O2) 2 (bisacetylacetonatomagnesium) installation line. By 2x10 to 5 Pa It is molecular-beam reinforcement about Se. At 1x10 to 4 Pa, it is O. Molecular-beam reinforcement At 1x10 to 6 Pa, it is NH3. An introductory line to N Molecular-beam reinforcement At 1x10 to 6 Pa, it is H from H2 installation line. It introduces by 1x10 to 5 Pa. It is 400nm of thickness by this growth process. : (OSe (MgZn)) Epitaxial growth of the p mold cladding layer of N is carried out. It is hexagonal and this p mold cladding layer is a lattice constant. It is a= 3.6A.
[0075] Next, it is molecular-beam reinforcement about Zn. At 1x10 to 4 Pa, it is molecular-beam reinforcement about Se. At 1x10 to 4 Pa, it is NH3. An introductory line to N Molecular-beam reinforcement At 1x10 to 5 Pa, it is H from H2 installation line. It introduces by 1x10 to 5 Pa. It is 200nm of thickness at this growth process. ZnSe: N Epitaxial growth of the p mold contact layer is carried out.
[0076] Next, the same processing process as an example 1 is performed, and it is the luminescence wavelength of 440nm near a room temperature. A double heterojunction mold semiconductor laser element is produced. The cross section of this element is shown in drawing 6 .
[0077] ZnO with near luminous layer and lattice constant Zn which has a lattice constant between this substrate and the above-mentioned luminous layer, using a single crystal as a substrate (OSe) Since the presentation dip buffer coat is used, they are O-Se and O-Te further. It is Zn (OTe) by adjusting the presentation ratio of a between. Barrier layer (OSe (MgZn)) The lattice matching between cladding layers was able to be acquired. For this reason, a good epitaxial growth luminous layer is obtained about a wide gap, it is efficient and the semiconductor laser element of highly reliable short wavelength can be obtained.
[0078] (Example 4) rare, after performing organic washing for a mirror-polishing alpha-SiC single crystal (product made from CREE) (hexagonal [of a= 3.08A]) -- HCl (0001) Light etching is performed. It is horizontal-type quartz ****** CVD about this substrate. It installs in equipment.
[0079] Next, the same epitaxial growth film production as an example 2 and a processing process are performed, and it is the luminescence wavelength of 400nm. A double heterojunction mold semiconductor laser element is produced. The cross section of this element is shown in drawing 7 .
[0080] It is Zn (OSe) by adjusting the presentation ratio between Mg-Zn and O-Se further, since alpha-SiC with near luminous layer and lattice constant is used as a substrate. Barrier layer (OSe (MgZn)) The lattice matching between cladding layers was able to be acquired. For this reason, a good epitaxial growth luminous layer is obtained about a wide gap, it is efficient and the semiconductor laser element of highly reliable short wavelength can be obtained.
[0081] (Example 5) (0001) Mirror-polishing single crystal ZnO rare, after carrying out organic washing of the substrate (product made from Litton Airtron) (hexagonal [of a= 3.25A]) -- HCl Light etching is performed. It is MBE about this substrate. It installs in equipment. It maintains at substrate temperature 400 ** under the back pressure of 1x10 to 8 Pa. It is molecular-beam reinforcement about Zn melting cel to Zn. By 1x10 to 4 Pa, from Mg(C5H7O2) 2 (bisacetylacetomagnesium) installation line by 8x10 to 5 Pa Mg molecular-beam reinforcement It is molecular-beam reinforcement about Se melting cel to Se. At 2x10 to 5 Pa, it is O from O2 gas installation line. Molecular-beam reinforcement At 2x10 to 6 Pa, it is molecular-beam reinforcement about aluminum(CH3) 3 installation line to aluminum. It introduces by 1x10 to 7 Pa. It is 200nm of thickness by this growth process. : (OSe (MgZn)) epitaxial growth of the n mold cladding layer of aluminum is carried out. This n mold cladding layer is band gap 3.4eV. It is hexagonal and is a= 3.25A in lattice constant.
[0082] It is molecular-beam reinforcement about Zn melting cel to Zn. At 1x10 to 4 Pa, it is Mg molecular-beam reinforcement from Mg(C5H7O2) 2 (bisacetylacetonatomagnesium) installation line. By 2x10 to 4 Pa It is molecular-beam reinforcement about Se melting cel to Se. At 1x10 to 5 Pa, it is O from O2 gas installation line. Molecular-beam reinforcement At 2x10 to 6 Pa, it is molecular-beam reinforcement about aluminum(CH3) 3 installation line to aluminum. It introduces by 1x10 to 7 Pa. It is 100nm of thickness by this growth process. : (OSe (MgZn)) epitaxial growth of the n mold guide layer of aluminum is carried out. This n mold guide layer is band gap 3.2eV. It is hexagonal and is a= 3.25A in lattice constant.
[0083] It is molecular-beam reinforcement about Zn. At 1x10 to 4 Pa, it is molecular-beam reinforcement about Se. At 1x10 to 4

Pa, it is O. Molecular-beam reinforcement It introduces by 1x10 to 6 Pa. It is 5nm of thickness by this growth process. Zn (OSe) Epitaxial growth of the non dope well layer is carried out. this well layer — band gap 2.9eV — hexagonal — lattice constant It is a= 3.6A.

[0084] It is molecular-beam reinforcement about Zn melting cel to Zn. At 1x10 to 4 Pa, it is Mg molecular-beam reinforcement from Mg(C5H7O2) 2 (bisacetylacetonatomagnesium) installation line. At 2x10 to 4 Pa, it is molecular-beam reinforcement about Se melting cel to Se. At 1x10 to 5 Pa, it is O from O2 gas installation line. Molecular-beam reinforcement It introduces by 2x10 to 6 Pa. this growth process — 5nm of thickness ** (MgZn) (OSe) Epitaxial growth of the non dope barrier layer is carried out. This barrier layer is band gap 3.2eV, It is hexagonal and is lattice constant a=3.3 **.

[0085] The deformation amount child well structure luminous layer of a repeat, a four layers well layer, and a three-layer barrier layer is formed for production of this well layer and a barrier layer.

[0086] It is molecular-beam reinforcement about Zn melting cel to Zn. At 1x10 to 4 Pa, it is Mg molecular-beam reinforcement from Mg(C5H7O2) 2 (bisacetylacetonatomagnesium) installation line. By 2x10 to 4 Pa It is molecular-beam reinforcement about Se melting cel to Se. At 1x10 to 5 Pa, it is O from O2 gas installation line. Molecular-beam reinforcement At 2x10 to 6 Pa, it is NH3 installation line to N. Molecular-beam reinforcement At 5x10 to 6 Pa, it is H from H2 installation line. It introduces by 2x10 to 5 Pa. It is 100nm of thickness by this growth process. : (OSe (MgZn)) N Epitaxial growth of the p mold guide layer is carried out. This p mold guide layer is band gap 3.2eV, It is hexagonal and is a= 3.25A in lattice constant.

[0087] It is molecular-beam reinforcement about Zn melting cel to Zn. At 1x10 to 4 Pa, it is Mg molecular-beam reinforcement from Mg(C5H7O2) 2 (bisacetylacetonatomagnesium) installation line. By 8x10 to 5 Pa It is molecular-beam reinforcement about Se melting cel to Se. At 2x10 to 5 Pa, it is O from O2 gas installation line. Molecular-beam reinforcement At 2x10 to 6 Pa, it is NH3 installation line to N. Molecular-beam reinforcement At 5x10 to 6 Pa, it is H from H2 installation line. It introduces by 1x10 to 5 Pa. It is 200nm of thickness by this growth process. : (OSe (MgZn)) N Epitaxial growth of the p mold cladding layer is carried out. This p mold cladding layer is band gap 3.4eV. It is hexagonal and is lattice constant a=3.3 **.

[0088] Next, it is molecular-beam reinforcement about Zn. At 1x10 to 4 Pa, it is molecular-beam reinforcement about Se. At 1x10 to 4 Pa, it is NH3. An introductory line to N Molecular-beam reinforcement At 1x10 to 5 Pa, it is H from H2 installation line. It introduces by 1x10 to 5 Pa. It is 200nm of thickness at this growth process. ZnSe: N Epitaxial growth of the p mold contact layer is carried out.

[0089] Next, the same processing process as an example 1 is performed, and it is the luminescence wavelength of 410nm near a room temperature. A deformation amount child well structure semiconductor laser element is produced. Drawing 8 shows the cross section of this element. ZnO Since the single crystal is used as a substrate and epitaxial growth of the n mold cladding layer of :(OSe (MgZn)) aluminum of high quality can be carried out, quality n mold guide layer, a deformation amount child well structure luminous layer, and p mold cladding layer can be obtained. Moreover, Mg-Zn-O-Se and Zn-O-Se By adjusting the presentation ratio of a between, the lamination of n mold guide layer, deformation amount child well structure, and p mold guide layer can be set up with a sufficient controllability.

[0090] By this invention, it is O to an II-VI group compound semiconductor material. By adding an element, the method of reconciling the lattice matching of the formation of a wide gap and substrate of a barrier layer is indicated. It is premised on zinc blend structure like the barrier layer of the conventional II-VI group compound semiconductor, and the crystal structure of a barrier layer is GaAs, InP and GaP, and ZnSe as a substrate. It is mentioned. Therefore, it is efficient and the semiconductor laser element of highly reliable short wavelength can be obtained with low threshold current.

[0091]

[Effect of the Invention] hexagonal in the semiconductor light emitting device of invention of claim 1 so that more clearly than the above explanation — ZnO Since exciton binding energy is large, and the exciton of high density exists also in a room temperature, high luminous efficiency can be expected. the luminous layer of this invention is hexagonal — ZnO Since it is the presentation of hexagonal Zn (Ox) (X=S, Se, Te) made into the subject, high luminous efficiency can be expected similarly.

[0092] Furthermore, since the above-mentioned luminous layer is the mixed crystal of plural systems, by changing a presentation, control the lattice constant of a luminous layer, a band band gap, and a refractive index in the large range, an extensive material selection - Combines, and selection of large luminescence wavelength is attained. When a luminous layer takes the configuration of a barrier layer-cladding layer, the grid consistency between barrier layer-cladding layer-substrates can be raised. For this reason, there are few interface defects, and the epitaxial growth phase of high quality is obtained and the semiconductor light emitting device of higher luminous efficiency and high reliability can be realized.

[0093] Moreover, when a luminous layer takes quantum well structure, the mismatch of a grid is permitted to the degree by which the grid of a well layer and a barrier layer is not destroyed. For this reason, more extensive selection and combination of a material, and selection of larger luminescence wavelength are attained, and a semiconductor light emitting device with the property which was [band / larger / lower threshold current, / modulation] excellent can be realized.

[0094] furthermore, Cd and Be etc. — not using the large material of effect by environment, a semiconductor light emitting device is producible with a material with little contamination to environment.

[0095] Invention according to claim 2 is Mg and Mn to a cladding layer and a barrier layer. Since at least one sort of elements are included inside, the band gap of a cladding layer is extended and a refractive index can be made small. Moreover, since a material serves as plural systems, control the lattice constant of a luminous layer, a band band gap, and a refractive index in the large range to a large area more, or selection of larger luminescence wavelength is attained, it is more highly efficient and a highly reliable semiconductor light emitting device can be produced.

[0096] For invention according to claim 3, p mold cladding layer is N. By including an element, a semiconductor light emitting device with the operation effect of claim 1 is realizable.

[0097] Invention according to claim 4 is aluminum 2O3 with this light emitting device that it can mass-produce and comparatively cheap. Since the substrate is used, the epitaxially grown cladding layer can be obtained and a semiconductor light emitting device with the operation effect of claims 1-3 can be realized.

[0098] Since invention according to claim 5 has hexagonal structure and uses the substrate which are a lattice constant a= 2.7 - 5.2 **, it can obtain the epitaxially grown cladding layer and can realize a semiconductor light emitting device with the operation effect of claims 1-3.

[0099] Invention according to claim 6 fulfills the conditions of claim 5, and is the available hexagonal structure ZnO and SiC. Since it uses for the substrate, the epitaxially grown cladding layer can be obtained and a semiconductor light emitting device with the operation effect of claims 1-3 can be realized.

[0100] Since the epitaxial growth phase of high quality is obtained more since the buffer coat which eases the mismatch of a grid

is prepared between the substrate and the cladding layer, and the interface defect of according to claim 7 invention between each class decreases, it can realize a semiconductor light emitting device with the operation effect of claims [that it is more efficient and high-reliability] 1-3.
[0101] that invention according to claim 8 is the same as that of a light-emitting part or Zn (X1) which consists of the same crystal structure as a similar element, and Zn (X1X2) (X1, X2=O, S, Se, Te), Since the buffer coat is prepared, in addition to the effect of claim 7, the electric and mechanical cementation between substrate-light-emitting parts becomes good, and a semiconductor light emitting device with the operation effect which are claims [that it is more efficient and high-reliability] 1-3 can be
[0102] furthermore, Zn (X1X2) (X1, X2=O, S, Se, Te) which consists of a 3 yuan or more element, Since the presentation inclined layer which changed the ratio of X1 and X2 continuously in the thickness direction in the case of the buffer coat of a presentation becomes realizable, these effects increase further and a semiconductor light emitting device with the operation effect which are claims [that it is more efficient and high-reliability] 1-3 can be realized.

[Translation done.]

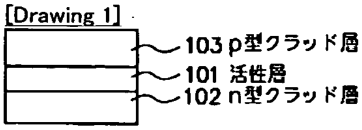
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the example of a basic configuration of the operation gestalt of the semiconductor light emitting device of this invention.
[Drawing 2] It is drawing showing the basic configuration of a double heterojunction mold.
[Drawing 3] It is drawing for grasping an epilogue and the physical properties of the mixed crystal of a compound semiconductor for between the plots of the physical-properties value of each compound semiconductor in a straight line.
[Drawing 4] Luminescence wavelength of 415nm of an example 1 It is drawing showing the cross section of a double heterojunction mold semiconductor laser element.
[Drawing 5] Luminescence wavelength of 400nm of an example 2 It is drawing showing the cross section of a double heterojunction mold semiconductor laser element.
[Drawing 6] Luminescence wavelength of 400nm of an example 3 It is drawing showing the cross section of a double heterojunction mold semiconductor laser element.
[Drawing 7] It is drawing showing the cross section of a double heterojunction mold semiconductor laser element with a luminescence wavelength [by epitaxial growth film production and the processing process of an example 4] of 400nm.
[Drawing 8] Luminescence wavelength of 410nm of an example 5 It is the element cross section showing a deformation amount child well structure semiconductor laser element.
[Description of Notations]
101 201 Barrier layer
102 202 n mold cladding layer
103 203 p mold cladding layer
204 Substrate
205 Buffer Coat
301 501 n mold Zn (OTe) barrier layer
302 N Mold Zn(OSe):Aluminum Cladding Layer
303 P Mold Zn(OSe):N Cladding Layer
304 404 2Oaluminum3 substrate
305 Zn (OSe) Buffer Coat
306, 406, 506, 606 p mold ZnSe:N contact layer
307, 407, 507, 607, 807 p mold electrode velum
308, 408, 508, 608 SiO2 insulator layer
309, 409, 509, 609, 809 n mold electrode
401 601 n mold Zn (OSe) barrier layer
402, 502, 602, 802 n mold (MgZn) (OSe): aluminum cladding layer
403, 503, 603, 803 p mold (MgZn) (OSe): N cladding layer
504 804 ZnO substrate
505 Zn (OSe) Presentation Dip Buffer Coat
604 SiC Substrate
801 Deformation Amount Child Well Structure Layer
802 N Mold (MgZn) (OSe); Aluminum Cladding Layer
803 P Mold (MgZn) (OSe) : N Cladding Layer
806 P Mold ZnSe:N Contact Layer
808 SiO2 Insulator Layer
811 Zn (OSe) Well Layer
821 (MgZn) Barrier Layer (OSe)
831 N Mold (MgZn) (OSe) Guide Layer
841 P Mold (MgZn) (OSe) Guide Layer

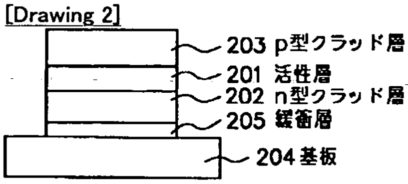
[Translation done.]

DRAWINGS

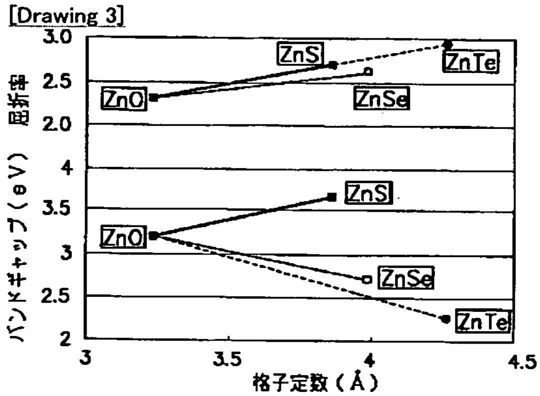
[Drawing 1]



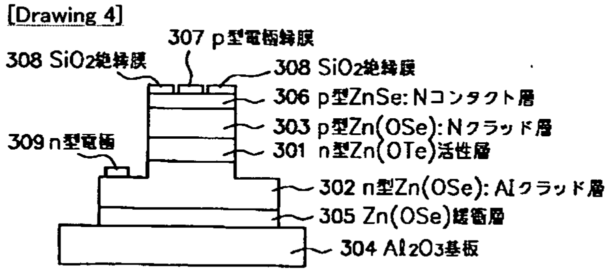
[Drawing 2]



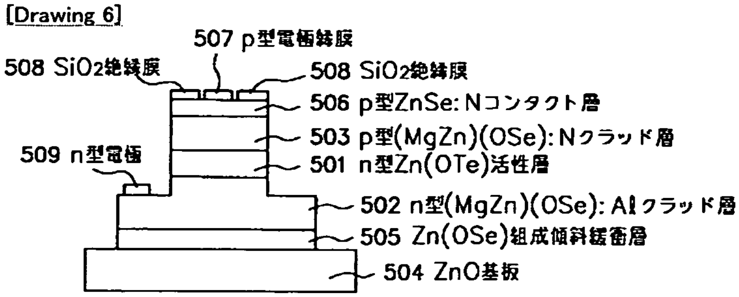
[Drawing 3]



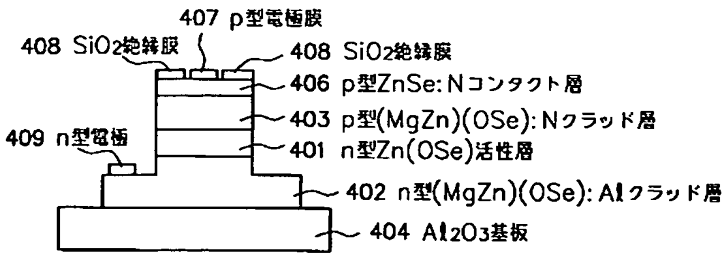
[Drawing 4]



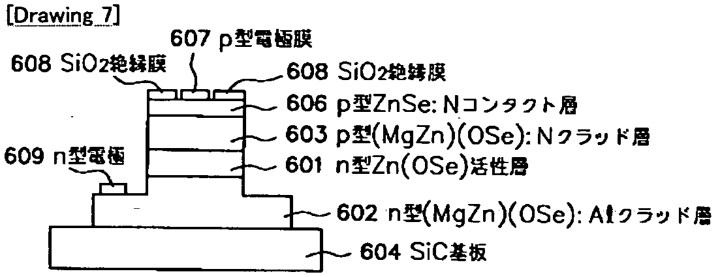
[Drawing 6]



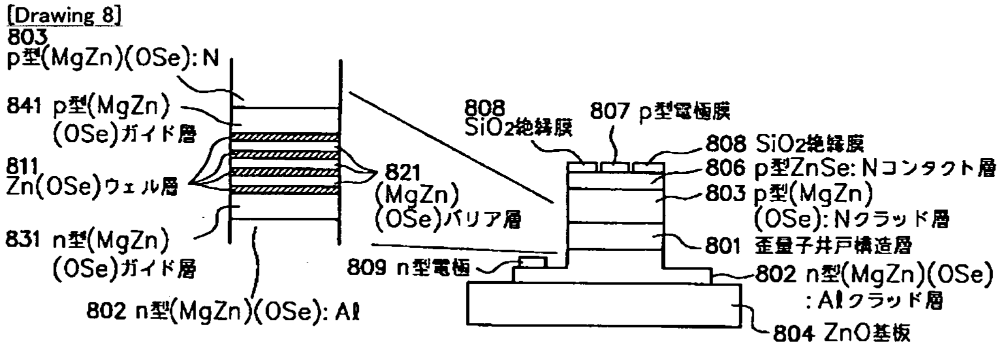
[Drawing 5]



[Drawing 7]



[Drawing 8]



[Translation done.]